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Original Communication

Urinalysis and hair analysis for illicit drugs of driver applicants and drivers in the trucking industry

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ABSTRACT

The purpose of this article is to compare the differential rate of detection of illicit drugs when using two distinct sample types, hair and urine specimens. The specimens were collected from persons who applied for employment as a truck driver, or were collected from randomly selected currently employed truck drivers. The data is examined for job applicants and employees to determine if any differences in outcomes are associated with employment status or specimen type. The data is also assessed for specific patterns associated with particular drugs and their assay outcomes. Overall, it was determined that drug positive cases are relatively rare. Job applicants are more likely to test positive for an illicit drug than a currently employed driver. Applicants are more frequently positive for a drug by a factor of 3 for both urinalysis and hair analysis when compared to currently employed drivers. Approximately 2% of applicants were urine positive and 9% hair positive for an illegal drug. Considering employed truck drivers 0.6% were drug positive by urinalysis and 3% when using hair analysis. It is concluded that hair assays detect more drug use than urinalysis. It is also concluded that when urine and hair assay outcomes are non-concordant the typical case is a positive hair analysis with a negative urinalysis.

1. Introduction

Among the duties of the medical examiner is the necessity to evaluate the circumstances of injurious or fatal vehicle accidents, typically by the examination of the physical evidence presented at the scene of the event, including toxicological reports. This paper examines one specific element related to these duties, the evaluation of drug intoxication by commercial truck drivers and those who seek employment as commercial truck drivers. Safety concerns within the transportation industry and the potential use of drugs by employee involves both economic liability and public safety concerns.[1] Transportation employees engaged in drug use present an enhanced risk to safe vehicular operation as well as being perceived as less productive in the work environment. The truck drivers we are considering here are the operators of very large commercial articulated trucks of 12–16 wheels and weight up to 150,000 pounds when fully laden. These vehicles are colloquially referred to as “semi’s” in the United States

Drug testing in the workforce is a well-established practice in the United States and as a consequence there have been a number of different assessments of technology and sample types as they may be applied to employee or pre-employment drug testing.[2] For the commercial trucking industry drug and alcohol intoxication is an especially important legal matter. The issue of public safety in the operation of these large mechanical entities is an important public health concern. In 2002 a field operation by law enforcement officers targeting large commercial trucks reported that of 1079 drivers checked by urinalysis 9.5% were positive for a CNS stimulant (amphetamines, methamphetamine, ephedrine, or cocaine) and 4.3% were positive for cannabinoids.[3] A recent United States Federal Motor Carrier Safety Administration study of accidents involving large commercial trucks reported approximately 13,091 fatal crashes nationwide over a three-year period 2005–2007.[4] A 2005 study of drug use by drivers of large trucks determined that 1.7% of a randomly selected sample provided by commercial trucking companies (representing approximately 420,000 drivers) were positive for a controlled substance.[5] When alcohol use was assessed the result showed an average of 0.225% positive over the same time interval. Thus truck drivers were more than 7 times more likely to be positive for a controlled substance than alcohol. There is also data, albeit limited, for pre-employment drug screening of persons applying to be truck drivers. These findings reported that in the year 2005 approximately 2.1% of truck driver job applicants tested urine positive for a controlled substance. These are substantial numbers, and therefore the evaluation of the potential intoxication of these workers does have a legitimate basis. Especially in the case

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of an accident an assessment of possible legal actions – both criminal and civil – depend in part on forensic examination of biological evidence, including the toxicological status of the truck driver.

2. Mandatory drug testing of drivers and applicants

In consideration of this, the United States government in 1989 mandated that commercial trucking companies must conduct random drug and alcohol surveillance of their truck drivers and screen all applicants for driving positions for drug use at the time of application for employment. This is required under the United States Federal Department of Transportation's (DOT) rule 49 CFR Part 40. This regulation also delineates the specific procedures for conducting the testing, the specimen types which may be used, and the threshold for determining what constitutes a positive drug test. In addition to pre-employment testing and a program of randomized testing of working drivers, it also requires post-accident and post-citation drug testing of involved drivers.

2.1. Specimen types: urine

Urine is the most widely used test specimen for determining illicit drug exposure in the United States. Urinalysis consists of an initial immunoassay screening of the specimen, typically radioimmunoassay or fluorescence polarization immunoassay. In cases where some individual decision is made such as termination of employment, etc. a confirmation test is done using GC/MS or an equivalent technology. The specimens in this study were screened for 5 commonly used illicit drugs; cannabis, cocaine, amphetamines, phencyclidine, and opiates. The federal government's Department of Health and Human Services has established threshold values to interpret a screening test as positive. These have been adopted by the Department of Transportation and are as follows: cannabinoids 50 ng/ml, cocaine 300 ng/ml, amphetamines 1000 ng/ml, PCP 25 ng/ml, and opiates 2000 ng/ml.

Under current American law there are a limited number of other (i.e., non-urine) specimens which also can be utilized for testing purposes. For alcohol testing, a breath analysis can be utilized. However, employers have almost exclusively relied upon urinalysis.

2.2. Specimen types: hair

Beyond urine the only other test matrix which has in recent years seen a substantial growth is the use of hair specimens. As a consequence in recent years the American government has considered widening the scope of approved specimen types to include sweat, hair, and saliva. Hair is a particularly interesting matrix because it has already achieved a relatively wide acceptance as a toxicological specimen in a number of forensic contexts, and because it offers a substantially longer retrospective window of detection compared to most other specimen types. Thus the primary advantage of hair analysis is that drugs captured in the hair are present there in recoverable quantities for a long period of time in contrast to urine, sweat, blood, or saliva. This is especially important in evaluating the rapidly metabolized and excreted drugs commonly abused – most notably cocaine, opiates, and amphetamines. In the trucking industry this is potentially appealing in that stimulants are considered at high risk to be abused since they increase wakefulness and allow drivers to drive for longer periods of time.

Hair used as a drug test specimen is typically collected from the scalp. Scalp hair growth is considered to average about 1 cm per month, with substantial variation depending on both individual and environmental factors.[6,7] In this study the samples collected were 3.84 cm or less measured from the proximal (scalp) terminus of the hair. It takes approximately 5 days for hair to erupt above the dermis, the hair samples analyzed cover an approximate time period of approximately 7–100 days prior to sample collection,[8] dependent on length of sample. Hair samples were cut at the level of the scalp from the posterior vertex of the head. The samples were protectively packaged and the proximal and distal ends of the hair were identified and labeled and the alignment of the strands was preserved. An important element in hair analysis is that is environmentally exposed. The determination of a positive outcome for a hair analysis requires the assessment of possible environmental contamination. The concentration of drug recovered from decontamination washing of the specimen is consequently factored into the evaluation of a specimen before an assignment of positive or negative is designated. A brief synopsis of the procedure is described as follows.

After retrieval and examination, the hair specimens are subjected to a specialized wash protocol to remove environmental contamination. The wash procedure consists of placing the hair in a dry isopropanol bath, shaken vigorously at 37 °C for 15 min. After 15 min, the isopropanol is removed to a separate tube and saved for later analysis. Subsequently, 2 ml of phosphate buffer at slightly acidic pH (range of 6.2–6.4) is added to the hair sample and is then shaken vigorously for 30 min at 37 °C. The buffer is removed and saved for later analysis. This 30-min wash is repeated twice. It is then followed by two 60-min washes using the same conditions. The last wash is saved and analyzed. The amount of drug per mg of hair in the last wash is multiplied by 5 (or 3.5 for methamphetamine), and this result is subtracted from the amount of drug per mg hair measured in the hair digest itself. The result of subtracting the indicated multiple of the last wash drug value from the digest value is termed the *wash criterion*, and is an estimate of the amount of drug that would remain in the hair if further washings were to be applied. After the final phosphate buffer wash and removal of the buffer, the hair sample is enzymatically digested, a melanin fraction is removed via centrifugation and the drug concentration measured in the digest. The wash criterion subtraction is then performed from the value of the digest concentration of the parent drug the hair sample. If the result after the subtraction is *less than* the cutoff for the parent drug, the result is considered negative in indicating drug use at the established threshold criteria. The threshold values applied to the final hair digest analysis in this study are as follows: cocaine, 5 ng/10 mg; opiates, 2 ng/10 mg; amphetamines, 5 ng/10 mg; cannabinoids, 0.01 ng/10 mg. The hair samples in this study were tested by the Psychemedics Corporation, a private toxicology laboratory specializing in hair analysis. The protocols for washing and testing of hair samples have been described in full detail elsewhere and it is beyond the scope of the present article to review them in their entirety. A complete discussion of these procedures and criteria can be found in Hill, Cairns, and Schaffer.[9–12]

3. Purpose of the current study

The current study examines the differential outcome in a large-scale drug monitoring program which utilized both scalp hair and urinalysis for the purposes of detecting illicit drug use. The testing was performed on samples collected by large and well-established commercial trucking companies to assure that their drivers met federal and state requirements. The purpose of this article is to compare the differential in detection of illicit drugs when using two distinct sample types, hair and urine specimens. These data are examined for any differences in patterns of outcomes associated with each specimen, and to look for specific patterns associated with particular drugs and their assay outcomes. Four specific hypotheses are proposed regarding the expected outcomes of these

comparisons, and these hypotheses are evaluated using the results of the specimen tests.

4. The drug assay data

The data set used in this analysis consists of 11,242 urine and hair samples collected from persons applying for employment in the trucking industry. Job applicants were all tested, and they account 9784 cases or approximately 87% of the cases considered here. Active truck drivers were selected at random and there are 1458 cases of this type accounting for approximately 13% of the data. As noted, the urine and hair samples were tested for a 5-drug panel. These were opiates, cannabinoids, cocaine, amphetamines, and phencyclidine (PCP).

5. Hypotheses

Because of its differential retrospective capacities, the use of hair analysis, in comparison to urinalysis, infers certain expected outcomes in the relative rates of detecting the illicit drugs. The most commonly used illicit substances are relatively rapidly excreted via the urine – for example the opiates, amphetamines, and cocaine. Urine samples, even after episodes of substantial use, are usually clear of these drugs and their metabolites in 48–72 h. Essentially, urine specimens are good sources for the detection of relatively recent drug consumption. The exception to the rapid excretion generalization is cannabinoids. Cannabis and its metabolites show up quickly in the urine and are also detected for relative longer time. This is believed to be so because they are lipid soluble and consequently are retained in body fat and leach somewhat slowly. It is well documented that cannabinoids may be detected for a much longer period of time in the urine when compared to opiates, cocaine, and amphetamines.[13]

Alternatively hair is a specimen which exhibits a much longer retrospective window for the drug detection. The hair specimens that we analyze here are scissor-cut at the scalp level. Since hair emerges above the skin about 5–7 days after synthesis in the follicle, hair analysis cannot detect drug consumption in the short term. However, it is generally true that once a drug is embedded in the hair it is extremely difficult to remove short of destroying the hair itself. Thus hair recovered by cutting from the scalp is relatively robust and can be used to detect drug use for a long period of time. In a few cases the recovery of drugs from the hair has been after an extraordinary length of time.[14]

The distinction between the short-term methods like urinalysis and long-term retrospective methods such as hair suggests several hypotheses regarding the expected outcome patterns when comparing a hair and urine sample taken simultaneously from the same person. Four are suggested here:

1. Hair analysis should, on aggregate, show higher rates of drug consumption among any given population than would urinalysis. This is based on the assumption that hair, covering a longer retrospective window, will identify drug use that would not be identified by urinalysis.
2. It is more likely that a person who has a drug positive urine sample for a specific drug will have a positive hair analysis, since the circumstances that would lead to a positive urine result with a negative hair result are relatively less plausible than the inverse. Such a finding would indicate that a person who did not have a long-term pattern of drug use was identified by a single urine test. This has been referred to as the "unluckiest user" scenario – that is a person who has only begun the use of drug is quickly identified by a test which has a narrow window of detection.
3. It is more likely that a person who has a negative hair analysis will have a negative urine outcome. This is the inverse of hypothesis #2. It is based on the argument that a person who has no long-term indication of drug use (i.e., does not have a positive hair test) will be more likely to have a negative urinalysis.
4. Of the illicit drugs now commonly used only cannabinoids are relatively slowly excreted via urine, while the other commonly used substances (cocaine, opiates, and amphetamines) are rapidly excreted. Additionally the concentration, and consequently recovery, of cannabinoids from hair is relatively low.[a] Thus it is likely that when a drug is detected in urine and not recovered in hair it is most likely to be a cannabinoid.

Table 1
Urinalysis results, pre-employment testing.

Urine test result		*N*	Percentage
Negative for all drugs tested		9598	98.10%
Urinalysis positive for…	Amphetamine, cocaine	1	0.01%
	Amphetamine/ methamphetamine	12	0.12%
	Cocaine	53	0.54%
	Cocaine, marijuana	8	0.08%
	Heroin	1	0.01%
	Marijuana	81	0.83%
	Methamphetamine	4	0.04%
	Opiates	2	0.02%
	PCP	2	0.02%
	Refusal	16	0.16%
	Sample rejected	4	0.04%
	Test failure	2	0.02%
	Total	9784	100.0%

6. Results: pre-employment screening of job applicants

6.1. Urinalysis

The percentage of persons who were urine positive for an illicit drug was relatively small – only 1.9% out of the nearly 10,000 applicants tested positive for some drug. The complete urinalysis results for pre-employment testing are reported in Table 1.

Of the 164 persons who tested positive, the most frequently detected drug in urine was marijuana. Eighty-nine applicants (54.3%) were positive for either marijuana alone (81 cases) or marijuana in combination with one additional drug (8 cases). Sixty-two persons (37.8%) were positive for cocaine alone (53 cases) or cocaine in combination with additional drugs (9 cases). The total of cocaine positive urinalysis cases was 62 (53 + 9) and they represent 33.3% of applicants who had a positive urine assay. The third most frequent detection was for stimulants other than cocaine – amphetamine or methamphetamine. A total of 17 applicants (10.4% of positive urine specimens) had one or more amphetamine compounds in their urine. If one combines both categories of stimulants (cocaine and amphetamines) then 78 of the drug positive applicants (47.6%) had a stimulating drug in the urine. Only five cases were urine positive for other types of drug (3 for opiates and 2 for PCP).

6.2. Hair analysis

The pre-employment data for hair analysis presents a considerably different picture from urinalysis. Table 2 presents the outcome of hair assays.

[a] For reasons not completely understood, cannabinoids concentrate in the hair at relatively low levels in comparison to opiates, cocaine, and amphetamines.

Table 2
Hair analysis results, pre-employment testing.

Hair test result		*N*	Percentage
Negative for all drugs tested		8614	88.03%
Hair assay positive for…	Amphetamine, cocaine	11	0.11%
	Amphetamine, cocaine, marijuana	1	0.01%
	Amphetamine, cocaine, PCP	1	0.01%
	Amphetamine, marijuana	4	0.04%
	Amphetamine, opiates	1	0.01%
	Amphetamine, Methamphetamine	74	0.76%
	MDMA	3	0.03%
	Amphetamine, methamphetamine, marijuana	1	0.01%
	Cocaine	525	5.37%
	Cocaine, heroin	4	0.04%
	Cocaine, marijuana	37	0.38%
	Cocaine, marijuana, opiates	3	0.03%
	Cocaine, opiate	5	0.05%
	Cocaine, amphetamines, Methamphetamine	1	0.01%
	Heroin	6	0.06%
	Marijuana	213	2.18%
	Marijuana, PCP	1	0.01%
	Opiates	25	0.26%
	Opiates, marijuana	1	0.01%
	PCP	1	0.01%
	Refused	45	0.46%
	Test failure	207	2.12%
	Total	9784	100.00%

There are 918 drug positive outcomes for the 9784 hair samples tested. This represents 9.6% of all hair samples tested which stands in sharp contrast to the percentage of positive urinalyses. Overall, the rate of drug positive hair assays is approximately 5 times that of urinalysis (9.6% versus 1.9%).

The most frequently detected drug in hair was cocaine. Five hundred and eighty-eight persons were positive for cocaine or cocaine in combination with additional drugs. Of these 588 hair assay cases "cocaine only" positive cases were 525 and 63 were cases of cocaine in combination with one or more additional drugs. Cocaine and cocaine-in-combination cases account for 64.05% of all positive hair assays. The third most frequent detection was for the stimulants amphetamine, methamphetamine, or MDMA. A total of 97 applicants had one or more amphetamine compounds in their hair. There were 74 cases which showed amphetamines alone in the hair and 23 cases where additional drugs were also present. If one combines all categories of stimulants (cocaine and amphetamine compounds) then 685 of the 918 drug positive applicants (74.16%) had a stimulating drug in the hair. Only seven cases were positive for other types of drug (6 for heroin, and 1 for PCP).

Two hundred and thirteen applicants were positive for marijuana alone. Forty-eight applicants had marijuana in combination with one or more additional drugs, so that a total of 261 persons had at least marijuana positive hair assays or marijuana in combination with another drug. Of all 918 drug positive hairs assays marijuana or marijuana-in-combination accounts for 28.43%.

Stimulant drugs are of special concern to the trucking industry, since drivers are generally motivated to drive for long periods of time in order to maximize their earnings or to maintain delivery schedules. The drug analysis data documents the prominence of stimulant drugs among the job applicants. The two types of test produce similar distributions – both technologies produce similar rate profiles – urine and hair assays both detect about the same percentage distribution of drugs for the samples tested. The distinction is that hair analysis detects many more cases in absolute numbers since it is looking at a longer retrospective period. This large rate in detection of absolute numbers is also enhanced because both cocaine and amphetamines are relatively rapidly excreted via the urine, but appear to bind stably with hair.

Table 3
Comparing hair and urine assay outcomes: pre-employment screening.

Pre-employment screening				
Any marijuana detected in urine?		Any marijuana detected in hair?		Total
		No	Yes	
	No	9495	200	9695
	Yes	28	61	89
	Total	9523	261	9784
Any cocaine detected in urine?		Any cocaine detected in hair?		Total
		No	Yes	
	No	9185	537	9722
	Yes	11	51	62
	Total	9196	588	9784

6.3. Comparing hair and urine outcomes, pre-employment testing

Table 3 reports the crosstabulations for hair and urine assays for the two most frequently detected drugs, marijuana and cocaine. Our purpose is to examine the agreement or concordance of the two technologies. We divide the table for discussion purposes into *concordant cases* (the diagonal transecting cells I and IV) and into *non-concordant cases* (the diagonal transecting cells II and III). By concordant is meant that both tests agree and by non-concordant, that one test is positive while the other is negative. Because hair has a relatively long retrospective window, we expect more cases to have a positive hair analysis coupled to a negative urinalysis, and few cases to have a positive urinalysis coupled to a positive hair analysis.

First, we note that hair analysis detects the presence of marijuana and cocaine more frequently than does urinalysis. In evaluating the concordance/non-concordance of the two separate assays we see the same pattern for each drug. Generally, the non-concordant outcome is one where the hair assay identifies a drug which is not identified by urinalysis. This is by far the dominant non-concordant outcome. There are also a small number of cases for both marijuana and cocaine which have a positive urinalysis and a negative hair assay. We will look more closely at these results when we evaluate the four hypotheses.

7. Results: random screening of employed drivers

As explained in the introductory section, trucking companies are required by law to use a randomized selection process to conduct drug tests on currently employed drivers. In the data analyzed here there are 1458 cases of randomly screened active drivers. The results of the urinalyses for these drivers are shown in Table 4. Nearly all of these drivers tested negatively. Of all urinalyses performed (and excluding refusals or test not performed), 99.4% were drug negative.

Table 4 indicates that of the 1455 randomly tested urine samples (3 drivers refused to provide specimens), only a very small fraction (9 samples or 0.62%) was positive for any drug. Of these 9 samples, 6 had at least one stimulant drug identified. In these 6 cases cocaine was present, either alone or in combination with methamphetamine or marijuana.

Table 5 reports the hair assay results for the same group of drivers. While still low in comparison to pre-employment screenings, the results of the hair analyses are substantively different than those obtained by urinalysis.

Table 4
Urinalysis results, random testing.

Urine test result		*N*	Percentage
Negative for all drugs tested		1446	99.17%
Urinalysis positive for…	Cocaine, methamphetamine	1	0.07%
	Cocaine	4	0.27%
	Cocaine, marijuana	1	0.07%
	Marijuana	3	0.21%
	Refusal	3	0.21%
	Total	1458	100.0%

Table 5 reveals that there were 44 drug positive hair samples (3.1%), and 1380 hair negative samples. Although still a low number, the percentage positive samples is about 5 times the rate measured for urinalysis (3.1% versus 0.62%). As with urinalysis, stimulant drugs dominate the drug positive cases, of the 44 positive hair samples, 39 (88.6%) had one or more stimulant drugs identified. Cocaine was the dominant drug, with 34 cases of cocaine or cocaine in combination with another drug identified by hair analysis.

Table 6 includes all 1458 cases of randomly selected drivers and compares the concordance of the two testing technologies for both marijuana and cocaine.

Table 6 presents an outcome pattern similar to that demonstrated in Table 3, where the pre-employments' samples were evaluated. Table 6, however, has a notably smaller number of cases since the random testing of drivers is a smaller portion of the data set and the rate of positive outcomes for employed drivers is lower than for job applicants. Thus it is difficult to place any substantive confidence in the random screening data given the few positives by either hair or urine assays. However, observation does reveal that some similarities with what was observed for the pre-employment data, namely a very large number of cases which are "double negatives" – that is, neither test detects an illicit substance. This is true for both marijuana (99.2%) and cocaine (97.4%). As was true with pre-employment cases, there are a small number of cases in which the urine specimen is positive for a drug that is not detected by the hair analysis. Out of the 1458 cases we see only 3 marijuana cases (0.20%) of this type and 4 cocaine cases (0.27%). When we consider non-concordant outcomes both groups show that this is most frequently a positive hair assay and a negative urinalysis. The rate of drug positive outcomes for hair samples for both cocaine and marijuana demonstrates this pattern, but it is more pronounced for cocaine detection than marijuana detection. If we consider non-concordant cases alone, the ratio of pre-employment screening for marijuana is 28/228 (about 12.2%) and for cocaine is 11/548 (about 2.0%). For randomly screened active drivers the ratio of non-concordant cases for marijuana is 3/11 (27.3%) and for cocaine is 4/36 (11.1%).

Table 5
Hair analysis results, random testing.

Hair test result		*N*	Percentage
Negative for all drugs tested		1380	94.65%
Hair analysis positive for…	Amphetamine, marijuana	3	0.21%
	Amphetamine, methamphetamine	2	0.14%
	Cocaine	31	2.12%
	Cocaine, marijuana	1	0.07%
	Cocaine, opiate	2	0.14%
	Marijuana	5	0.35%
	Refused	4	0.27%
	Test not performed	30	2.05%
	Total	1458	100.00%

Table 6
Comparing hair and urine assay outcomes: random screening.

Random Screening of Active Drivers				
Any marijuana detected in urine?		Any marijuana detected in hair?		Total
		No	Yes	
	No	1446	8	1454
	Yes	3	1	4
	Total	1449	9	1458
Any cocaine detected in urine?		Any cocaine detected in hair?		Total
		No	Yes	
	No	1420	32	1452
	Yes	4	2	6
	Total	1424	34	1458

These are patterns which persist regardless of whether the samples are from job applicants or active employees. The modal category in both cases consists of those who test negative regardless of assay type. Hair analysis consistently detects more drugs than do urine specimens, and this differential is especially pronounced when cocaine is the examined drug. The size of the differential detection between hair and urine is reduced when marijuana is the drug under examination, although hair still tends to detect more marijuana use than urine.

8. Evaluating the hypotheses

Four hypotheses were stipulated for this analysis. They, in brief, are summarized as follows:

1. Hair analysis should, on aggregate, show higher levels of drug consumption than would urinalysis.
2. It is more likely that a person who has a positive urine sample for a specific drug will have a positive hair analysis.
3. It is more likely that a person who has a negative hair analysis will have a negative urine outcome.
4. It is likely that when a drug is detected in urine and not recovered in hair it is most likely to be a cannabinoid than a rapidly excreted drug such as cocaine.

In regards to hypothesis 1, the data here clearly support this conjecture. Hair assays in both the pre-employment and random screening pools reported substantively higher numbers of positive outcomes. When examining the pre-employment group we note that the overall percentage of detections by hair assay is greater than that of urine by a five-fold increase – hair detecting a drug in 9.6% of the samples while urine detected a drug in 1.87% of the samples. This is an expected outcome which can largely be attributed to the longer retrospective capacity of hair to identify drug use.

Hypotheses 2 and 3 are affirmed by this data in a limited fashion. The hypotheses are supported for the pre-employment data, but not for the random screen data. However, the number of drug positive assays for the random data set is extremely small. Out of 1458 random screenings for cannabis there were only 4 positive cannabis urinalyses and 6 positive cocaine urinalyses, thus it is difficult to place any meaning on the random screening data. Pre-employment positive cases, with more robust numbers, do show a pattern of outcome consistent with hypotheses 2 and 3. The basis of these hypothesized outcomes is derived from the same principle – the longer retrospective ability associated with hair as a sample. Hypothesis 2 assumes that a person who is a current drug user (i.e., they have a positive, current urine test) is more likely to be a chronic user of drugs. One would expect a person currently using

drugs (as indicated by a positive urine test) is likely to have a history of drug use. We believe this is a reasonable scenario in characterizing a person who appears for a job interview – knowing they will be drug tested – and has a positive urinalysis. We believe it is a less plausible scenario that a person who has no substantial history of chronic drug use would initiate such use within a day or two prior appearing for a job interview. Such a person would then appear as a "urine positive/hair negative" outcome which this data shows to be a rare outcome. In that sense hypothesis 3 is, overall, supported by this data. A negative hair assay with an associated positive urinalysis is generally the rarest form of outcome.

This "rare outcome" is addressed in hypothesis 4. If the most important factor in the discrepant outcomes between hair and urine assays is related to the rapid excretion drugs via urine, then we would expect to find in most cases these relatively rare discrepant outcomes (i.e., a positive urine/negative hair) to be cannabinoids. The reason for this is two-fold. First, cannabinoids are not rapidly excreted via urine relative to cocaine and amphetamines. Thus they are likely to be detected in the urine for longer periods of time. In chronic users of cannabinoids the detection of these substances in urine has been reported as long at several weeks after the last reported episode of use.[13] Secondly, cannabinoids are the most difficult substance of the commonly used drugs to detect in hair. Cannabinoids collect in hair at concentrations much lower than stimulants and require especially intense analysis to detect.[15,16]

How else might one account for the general conditions under which a short-term detection (urinalysis) reveals the presence of a drug not revealed by a longer term detector (hair)? It may be explained in some circumstances by the individual's cycle of drug use along with the length of recoverable hair. The retrospective capacity of hair is a function of its length. So an individual with very short hair may not present a particularly notable advantage over the use of urinalysis in detecting cannabinoids. Since the hair must emerge above the scalp, as we have already noted, there is a period of time in which hair will not detect drug use because it is not yet accessible to be sampled by cutting. During this same time cannabinoids may be readily detected in the urine. So a combination, for example, of very short scalp hair, coupled with only episodic or moderate or low levels of cannabinoid use can readily account for the cannabinoid pattern found in cell III, a failure to find a drug in the hair that is readily found in the urine.

The findings reported here are modestly consistent with the prediction posited by hypothesis 4, which stated that urine positive/hair negative samples were most likely to be the positive for cannabinoids when contrasted to cocaine. An analysis of the non-concordant cells in Table 3 reveals that non-concordant outcomes where the urinalysis results is cannabinoid positive (but negative for cannabinoids in hair) are about 2.47 times more likely to occur than a non-concordant outcome for cocaine. Simply put, it is more likely that if one has an outcome where the urinalysis is positive and the hair negative, this is more likely to be a cannabis positive urine than a cocaine positive urine.

9. Summary

This article has evaluated the outcome of drug testing of two groups in the trucking industry – those who apply for employment as truck drivers and those who are active truck drivers. Presenting this data has several purposes. First we wish to simply establish a baseline of data in this important and critical industry. We can reasonably surmise that the occurrence of drug positive applicants and drivers is relatively rare, whether measured by either urinalysis or hair analysis. The use of urinalysis reveals that slightly less than 2% of applicants are positive, while the use of hair analysis reveals that slight more than 9% are positive. When looking at active drivers, urinalysis reveals that this group is even less likely to test positive for a drug. Slightly less than 1% test urine positive for any of the 5 major psychoactive drugs, while hair analysis indicates slightly less than 3% are drug positive.

In examining the concordance of these outcomes, we find that most tests are concordant, with the large majority of cases being negative on both tests for both groups. When examining non-concordant cases, the data indicates that most non-concordant cases are "hair positive/urine negative", a combination which is most likely due to the longer retrospection which is associated with hair analysis. These findings are consistent between both the pre-employment group and the randomly screened group. Non-concordant cases of a negative hair assay and a positive urine assay are relatively rare. When they occur, they are most likely to involve cannabinoids. This suggests several potential applications of each technology to the issue confronting the commercial transportation industry. For short-term detection of most commonly abused trucks urinalysis would appear to be an adequate approach – especially if applied in a rigorously operated random drug screening program. Hair analysis quite clearly will detect more drug use, however, given its longer retrospective capability. This feature is especially useful in situations where the target group to be monitored can anticipate the use of a drug test, and therefore could enter a brief period of abstinence and produce a negative urinalysis. A germane example is in pre-employment interviewing. An applicant is typically aware that a drug screen will be done at the time of application/interview. In these circumstances a hair analysis is far more likely to be revelatory of drug use than urinalysis. One additional consideration applicable to the trucking and transportation industry is the relative popularity and potential motives to use CNS stimulants, typically amphetamines and cocaine. Because of the rapid excretion of these drugs hair analysis is likely to be more efficacious in detecting their presence and therefore might be a preferable technical choice when detection of stimulants is one of the primary objectives of the testing policy.

Conflict of Interest

The author has no conflicts of interest.

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Ethical Approval

This paper uses secondary data analysis which does contain any identifiers or either subjects or organizations. As such it is exempt from human subjects review.

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